Electronic Fuse

protection 'deluxe'

Design by U. Licht

In the hectic of 'just a quick test' the voltmeter probe slips off the voltage regulator pin, causes a short circuit and a handful of expensive semiconductors to give up the ghost. Although the short-circuit proof benchtop power supply will protect itself, it will briefly pump enough current into the load to cause extensive damage. The circuit described here was designed to act as a fuse, but one that's resettable, adjustable and fast-acting.

Note: this circuit has not been tested in the *Elektor Electronics* design laboratory. (*Ed.*)

Even a cursory look at the circuit diagram in **Figure 1** should convince most of you that this is not the umpteenth run of the mill electronic fuse circuit. The 'fuse' is a BTS432E2 from Infineon, whose datasheets may be found at www.infineon.com/cmc_upload/0/000/008/685/bts432e2.pdf)

This component from the PROFET series is basically an n-channel power FET with a lot of safety features built in. In normal operation, the FET is switched on and off via

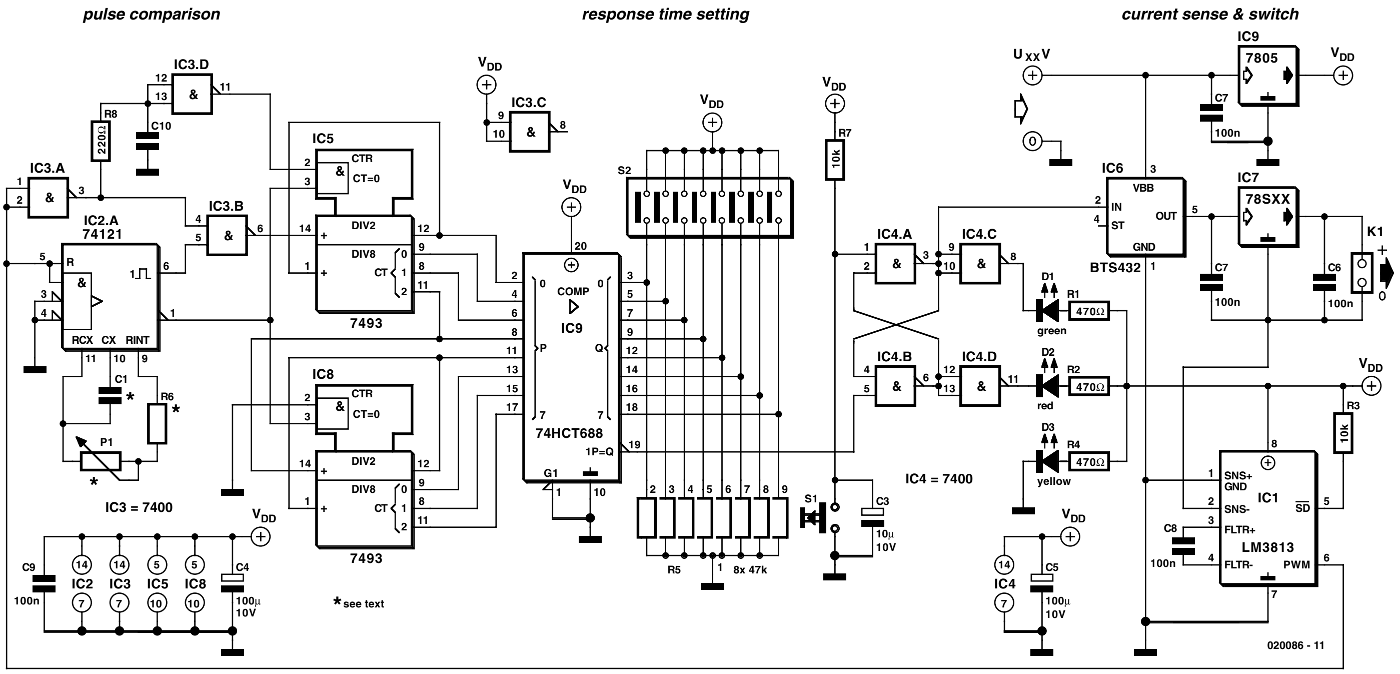

Figure 1. The circuit, which may be divided into sections referred to by 'pulse comparison', 'response time setting' and 'switch/current sensing'.

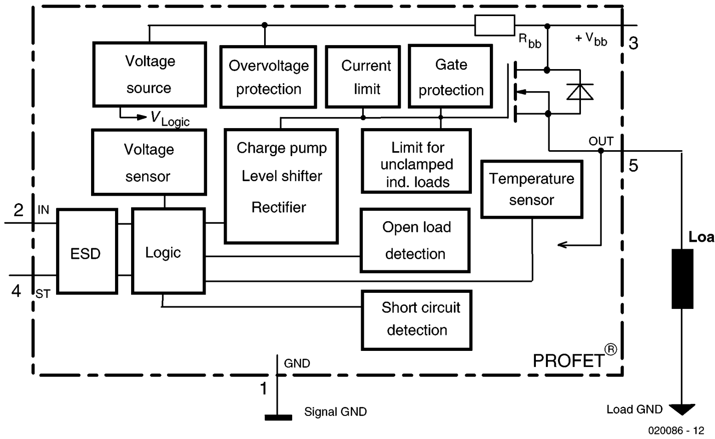

Figure 2. Internal workings of the PROFET.

the IN input. However, if either overvoltage or undervoltage condition arises, a short circuit to Vbb or ground, an open out output or a too high temperature, the BTS432ES takes its own measures against damage. A block diagram of the device is given in **Figure 2**.

The second essential component is the 'switching and current sensing' department is the LM1813 in position IC1. This precision current source monitors the current flow in the ground rail, introducing a minimum voltage drop itself. Its PWM output signal is a measure of the current flow through the Sense– and Sense+ pins. A positive current causes a pulse width ratio of 0.5 (at 0 A) to 0.955 (at 1 A). If a current is measured in the opposite direction, the pulse width ratio becomes 0.5 to 0.045 (at –1 A). The LM1813 is available in two versions: one for ±1 A and another for ±7 A. Its response time (which implies the delay between an overload condition and the IC signalling it) is about 50 ms. For an even faster electronic fuse, you may want to use the LM3813, which is marked by a response time of just 6 ms. The respective datasheets (with information on High-Side measurements) may be found on the National Semiconductor website at

www.national.com/ds/LM/LM3812.pdf
www.national.com/ds/LM/LM3814.pdf

IC9 is an ordinary fixed voltage regulator, supplying a regulated +5 V rail to the electronics in the fuse circuit. IC7 determines the actual output voltage.

Comparisons and values

The PWM signal — whose on/off ratio is a measure of the load current — is fed to monostable multivibrator circuit IC2. The LM3813 triggers the MMV type 741121 (IC2) every 50 ms. At the outputs we find a pulse (PMAX), whose length depends on the setting of pot P1.

The PWM signal is inverted by IC3a and then compared with PMX in IC3b. As long as the load current is within the allowable range, the output of IC3b remains High. If not, a Low pulse is produced as long as the PWM exceeds PMAX.

The Low pulses clock the cascaded 4-bit counters type 7493. The delay of $\overline{\text{PWM}}$ by the R-C network and IC3d ensures that the PWM pulse is actually recognised s a clock pulse before IC2 is able to supply a comparison pulse. In other words, the delay compensates the response time of the 74121.

The two binary counters are connected to an 8-bit magnitude comparator type 74HCT688. Its output, $\overline{\text{P=Q}}$, goes active (Low) when the counter value at the P inputs equals the (binary) value a the Q inputs. The latter value is determined by you, the user, by means of the DIP switch in the circuit. Using the 50-ms version of the current detector IC, the response time of the electronic can be set to 50 ms to 12.8 s in 50-ms increments. When the 6-ms version is used, the range is 6 ms to 1.5 s in 6 ms increments.

If the allowable current is exceeded before the preset counter value is reached (i.e., the load current drops below the maximum again), the counter is reset to 0 via the inverting output of the 74121. in other words, the fuse does not react to current surges which last shorter than the user-defined response time.

The $\overline{\text{P=Q}}$ pulse causes flip-flop IC4 to be set. In turn, the flip-flop switches off the supply voltage to the load via IC6. The flip-flop is reset by pressing the pushbutton.

LEDs D1, D2 and D3 indicate the fuse status: yellow = 'on'; green = 'current below trip level'; red = 'fuse activated, load disconnected'.

Practical use

The Electronic Fuse may be used in two basic circuit configurations. Either the unregulated voltage source is fused and the voltage regulator connected behind the fuse, or a regulated voltage supply is protected by the Electronic Fuse. This requires the positive output to be connected to IC6.

(020086-1)

IC1	Max. current	Response time	C1	P1	R6
LM3813M-1.0	±1 A	50 ms	1 µF	30-40 kΩ	2 kΩ
LM3813M-7.0	±7 A	50 ms	1 µF	30-40 kΩ	2 kΩ
LM3815M-1.0	±1 A	6 ms	100 nF	40 kΩ	wire
LM3815M-7.0	±7 A	6 ms	100 nF	40 kΩ	wire

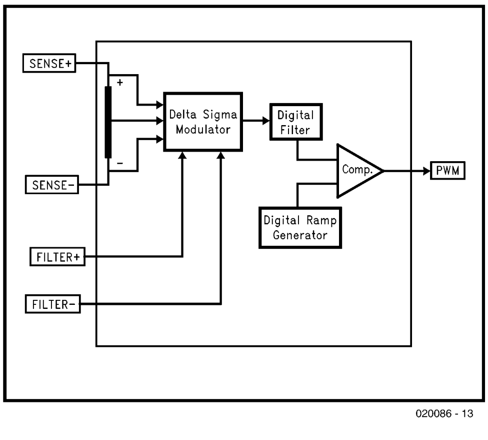

Figure 3. Curent measurement using LM1813/LM3813.